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Effect of Nutrient Management Practices on Growth, Yield and Economics of Vegetable Indian Bean and its Residual Effects on Fodder Pearl Millet under Vegetable Indian Bean–Fodder Pearl Millet Cropping System

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ABSTRACT

A field experiment was conducted in vegetable Indian bean (*Dolichus lablab* L.)–Fodder Pearl millet (*Pennisetum glaucum* L.) cropping sequence under integrated nutrient management at Navsari Agricultural University, Navsari, Gujarat, India during the *rabi* seasons (November to February) of 2019–20 and 2020–21 and summer seasons (March to May) of 2020 and 2021. It consisted of six INM treatments applied to vegetable Indian bean during *rabi* season as main plot treatments replicated four times in randomized block design and during summer season each main plot treatment was splited into three sub-plot treatments with three levels of RDF to fodder pearl millet resulting in eighteen treatment combinations replicated four times in split plot design. The experiment was conducted on the same site without changing the randomization of the treatments for the successive year to assess the residual effects. On the basis of two year pooled results, almost all the growth attributes, yield attributes and yield, net returns and B:C ratio were found significantly superior with the treatment T_1 (100% RDN through chemical fertilizer+5 t ha^{-1} of FYM) in vegetable Indian bean. Similarly, during summer season, the residual effect of INM treatments applied to preceding vegetable Indian bean, the treatment T_1 (100% RDN through biocompost) recorded significantly higher growth attributes, yield attributes and yield, net returns and B:C ratio in fodder pearl millet but it remained on par with the treatments T_6 and T_5. Whereas, direct application of fertilizer levels applied to fodder pearl millet in summer season, the treatment consisting of 100% RDF (F_3) recorded significantly higher values of growth, yield, net returns and B:C ratio.

KEYWORDS: Pearl millet, biocompost, biofertilizers, FYM, Indian bean, PSB, *Rhizobium*

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1. INTRODUCTION

Pulses are the main source of vegetable protein in India and are an integral part of Indian dietary system because of its richness in proteins and other important nutrients such as Ca, Fe and vitamins viz., carotene, thiamine, riboflavin and niacin (Dayakar et al., 2017, Longvah et al., 2017, Rao et al., 2021). Indian population is predominantly vegetarian and protein requirement for the growth and development of a human being is mostly met with pulses. They are said to be poor man's meat and rich man's vegetables (Shukla and Mishra, 2020). Apart from the human diet, pulses form an important fraction of cattle feed and fodder as hay, green fodder and concentrates (Meena et al., 2018). According to the Indian Council of Medical Research 40 g of pulses is the recommended daily intake for balanced diet for an average sedentary man (Priya, 2016, Ariappa et al., 2010). The total production of pulses in India was 13.38 mt, which increased to 25.58 mt during 2020–21. Gaur, 2021). The green tender pods are used as vegetable and commonly known as 'Balar' and 'Valpapdi'. It is also a kind of legume rich in protein content (Habib et al., 2017) such condition is due to big capacity of D. lablab nitrogen fixation. There are also found a number of bioactive compounds that are very advantageous to cure such particular diseases as liver problems (Kim et al., 2017), (Im et al., 2016), diabetes (Ahmed et al., 2015), and tumor (Vigneshwaran and Thirusangu, 2017). In Gujarat, a new variety of Indian bean i.e., GNIB-22 released in year 2017 and found most promising for vegetable purpose due to its short stature, early picking and short maturity with higher sugar (24.1 mg g^{-1}) and better optimistic test and suitable as an intercrop.

Fodder pearl millet is one of the best options for sustainable fodder production under irrigated condition (Kumar et al., 2012, Hassan et al., 2014, Jukanti et al., 2016, Raval et al., 2015). It is being emphasized due to its profuse tillering habit, multi-cut nature, drought tolerance, resistance to insect pest and disease and absence of poisonous prussic acid, good performance even in poor soil, good per day productivity and leafiness (Raval et al., 2014). It requires less water per unit of forage growth tolerates lower and higher concentrations of soil pH and aluminum and is rich in minerals (Harinarayana et al., 2003). It is a cereal fodder crop and responds well to nitrogen because nitrogen is one of the basic plant nutrients for profuse growth (Singh et al., 2012).

There is a scope to enhance the soil and crop productivity with the judicious use of all the major sources of plant nutrients in an integrated approach to get maximum yield without any deleterious effect on physico-chemical properties of soil (Jat et al., 2015). Intensified cropping system has high turnover of nutrients, poor recycling of organic sources and application of high analysis fertilizers caused deficiency of several micronutrients in soil and lead to environmental pollution (Nayyar et al., 2001, Mahmood et al., 2017). Organics alone do not produce spectacular increase in crop yields due to their low nutrient status. Therefore, to maintain soil productivity on a sustainable manner, blending of organic and inorganic sources of nutrients and pulses-based crop sequence needs to be adopted. In this context, cropping system approaches gaining importance (Saini and Kumar, 2014). Keeping these above points in view, the present investigation was undertaken to find out the effect of integrated nutrient management system on growth, yield, economics and appropriate nutrient combination in vegetable Indian bean–fodder pearl millet cropping sequence.

2. MATERIALS AND METHODS

A field experiment was carried out at college farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India during the *rabi* seasons (November to February) of 2019–20 and 2020–21 and summer seasons (March to May) of 2020 and 2021. The experimental field was clayey in texture and low in organic carbon (0.41%) and available N (198.40 kg ha^{-1}), medium in available P_2O_5 (37.98 kg ha^{-1}), very high in available K_2O (313.83 kg ha^{-1}), respectively. The soil was slightly alkaline in reaction (pH 8.03) with electrical conductivity (0.30 d Sm^{-1}).

The field experiment consisted of integrated nutrient management treatments *viz*., T_1: 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM, T_2: 75% RDN through chemical fertilizer+25% RDN through biocompost, T_3: 75% RDN through chemical fertilizer+25% RDN through biocompost+seed treatment with PSB and *Rhizobium* biofertilizers, T_4: 50% RDN through chemical fertilizer+50% RDN through biocompost, T_5: 50% RDN through chemical fertilizer+50% RDN through biocompost+seed treatment with PSB and *Rhizobium* biofertilizers and T_6: 100% RDN through biocompost to vegetable Indian bean GNIB-22 was sown @ 25 kg ha^{-1} with spacing of 45×20 cm^2 in *rabi* season as main plot treatments replicated four times in randomized block design resulting in twenty four treatments. During summer season each main plot treatment was splited into three sub-plot treatments with three levels of recommended dose of fertilizers *viz*., F_1: 50% RDF, F_2: 75% RDF and F_3: 100% RDF to fodder pearl millet GAFB-4 was sown @ 12 kg ha^{-1} with spacing of 30×10 cm^2 resulting in eighteen treatment combinations replicated four times in split plot design. The experiment was conducted on the same site without changing the randomization of the treatments for the successive year to assess the residual effects. The mean meteorological data on maximum and minimum temperatures, morning and evening relative humidity, sunshine hours and evaporation were recorded during *rabi* and summer season of 2019–20 and 2020–21 are presented in Table 1.

Table 1: Meteorological data recorded during the cropping seasons of 2019–20 and 2020–2021

Year	Temperature (°C)		R.H. (%)		Sunshine hrs. day^{-1}	Evaporation (mm)
	Maximum	Minimum	Morning	Evening		
Rabi season						
2019-20	27.5-34.4	8.4-19.3	76.4-91.3	39.4-68.6	4.5-9.2	7.8-10.7
2020-21	28.4-35.0	10.7-18.1	74.5-95.2	33.8-73.5	3.2-9.3	2.9-10.4
Summer season						
2019-20	30.7-38.0	16.1-26.3	79.1-95.6	41.8-63.2	1.4-4.2	4.0-7.1
2020-21	34.1-38.1	14.1-25	79.2-94.6	31.8-67.5	1.3-4.6	3.4-5.9

The required quantity of organic fertilizers *viz*., well decomposed FYM and biocompost was incorporated and mixed well within the soil at the time of land preparation during both the years. Before application of organic manures, it was analyzed for N, P_2O_5 and K_2O content and is presented in Table 2.

Table 2: Chemical composition of organics (dry weight basis)

Sl. No.	Organics	Year	Nutrient content (%)		
			N	P_2O_5	K_2O
1.	FYM	2019	0.53	0.34	0.51
		2020	0.61	0.42	0.57
2.	Bio-compost	2019	0.45	0.14	0.46
		2020	0.44	0.14	0.47

The RDF (20:40:00 kg NPK ha^{-1}) was applied through urea (46% N) and common dose of 40 kg P_2O_5 was applied through single super phosphate (16% P_2O_5) in vegetable Indian bean. While, the RDF (100:00:00 kg NPK ha^{-1}) was applied through urea (46% N) in two splits; first 50% N at the time of sowing and remaining 50% N was top dressed at one month after sowing of fodder pearl millet during both the years, respectively. The quantity of manures applied during the cropping seasons of 2019–20 and 2020–21 are presented in Table 3.

The data on growth and yield attributing parameters of preceding *rabi* Indian bean and succeeding summer fodder pearl millet were collected at various stages of the crop

Table 3: Quantity of manures applied during the *rabi* and summer season of 2019–20 and 2020–21

Treatments	Nutrient	Form	Source	Rate ha^{-1}	Quantity (kg) UREA/ SSP/ FYM/ BC
T_1	Nitrogen	Inorganic	Urea	20	43.50
		organic	FYM	-	5000.00
	Phosphorus	Inorganic	SSP	40	250.00
T_2	Nitrogen	Inorganic	Urea	15	32.62
		organic	Biocompost	5	1111.00
	Phosphorus	Inorganic	SSP	40	250.00
T_3	Nitrogen	Inorganic	Urea	15	32.62
		organic	Biocompost	5	1111.00
	Phosphorus	Inorganic	SSP	40	250.00
	Biofertilizers	organic	PSB and *Rhizobium*	250 ml each	250 ml each
T_4	Nitrogen	Inorganic	Urea	10	21.70
		organic	Biocompost	10	2222.00
	Phosphorus	Inorganic	SSP	40	250.00
T_5	Nitrogen	Inorganic	Urea	10	21.70
		organic	Biocompost	10	2222.00
	Phosphorus	Inorganic	SSP	40	250.00
	Biofertilizers	organic	PSB and *Rhizobium*	250 ml each	250 ml each
T_6	Nitrogen	Inorganic	Urea	0	0
		organic	Biocompost	20	4444.00
	Phosphorus	Inorganic	SSP	40	250.00
F_1	Nitrogen	Inorganic	Urea	50	108.70
F_2	Nitrogen	Inorganic	Urea	75	163.05
F_3	Nitrogen	Inorganic	Urea	100	217.40

season, were analysed with Randomized Block Design and Split Plot Design, respectively and then determined and statistically analysed using the appropriate procedure (Panse and Sukhatme, 1967). The data collected from the experiment on various observations were subjected to pooled analysis as prescribed by Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1. Effect of integrated nutrient management on vegetable Indian bean

3.1.1. Growth parameters

All growth parameters of vegetable Indian bean *viz*., Plant height, Number of leaves plant^{-1}, Number of branches plant^{-1}, Dry matter accumulation (g plant^{-1}) were influenced significantly due to use of various integrated nutrient management practices (Table 4). However, days to 50% flowering was showed non significant effect of treatments. The application of 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM (T_1) was found to be superior and recorded significantly higher values for almost all the growth attributes as compared to rest of the treatments while, the lowest values were obtained under the treatment T_6 (100% RDN through biocompost) in two-year pooled results. Almost all these growth attributes remained in $T_1 > T_3 > T_5 > T_2 > T_4 > T_6$ order of their significance. This may be due to conjunctive use of organic manure, biofertilizer and inorganic fertilizers that improved the physical and chemical properties of soil by increasing the organic carbon, nitrogen, phosphorus and potassium content in the soil lead to improve the availability of nutrients over a longer period of crop duration owing to their slow release. Similarly, nitrogen application facilitated vegetative growth and being a constituent of the plant cell influenced different physiological processes such as cell division, cell elongation and chlorophyll production. Likewise, seed treatment with PSB and *Rhizobium* biofertilizers help in root nodulation in leguminous crops results in nitrogen fixation that fulfil nitrogen requirement at later growth stages which reflected in improvement in the primary growth parameters resulted on improvement in the dry matter accumulation. Almost similar results were also observed by Ananth and Kumar (2018) that the highest growth parameters were recorded with 5 t Vermicompost ha^{-1}+75% RDF+CBF and it was on par with 5 t Vermicompost ha^{-1}+100% RDF+CBF in Indian bean, Jaisankar and Manivannan (2018) noticed that application of NP 30:50 kg ha^{-1}+5 t vc ha^{-1}+BF 2.5 each kg ha^{-1}) recorded significantly highest number leaves plant^{-1} and number of branches plant^{-1} with respect to Indian bean, Mere et al. (2013) revealed that soybean revealed that fertilized with 125% RDF+5 t ha^{-1} FYM has recorded maximum CGR, RGR, NAR. Sushil et al. (2015) reported that application of 100% RDF+ vermicompost @ 1.25 t ha^{-1}+Azatobactor @ 375 g ha^{-1} recorded significantly plant height (cm) 25 days (28.62) and 50 days (44.17), number of leaves 25 days (13.37) and 50 days (22.10), number of branches 25 days (3.34) and50 days (5.44) and days of 50% flowering (41.24). Meena et al. (2016) noted that growth was maximum with 20 N, 40 P_2O_5, 40 K_2O+FYM 10 t ha^{-1} and Rhizobium in green gram and Chauhan et al. (2016) reported that the growth parameters plant height (56.66 cm), number of leaves (70.06), branches (12.73), internodal length (3.26 cm) and leaf area (6.53 cm^2) per plant were maximum by application of (75%) RDF+biofertilizers (*Rhizobium*+ PSB) with regards to cowpea.

Table 4: Growth attributes of vegetable Indian bean as influenced by as influenced by different INM treatments

Treatments	Plant height	No. of leaves plant^{-1}	No. of branches plant^{-1}	Dry matter accumulation (g plant^{-1})	Days to 50% flowering
T_1	72.44	141.54	10.72	55.79	57.06
T_2	59.42	121.15	8.45	46.70	54.41
T_3	64.06	125.98	9.66	50.81	55.21
T_4	56.66	117.70	8.23	45.64	54.68
T_5	60.01	123.47	9.11	47.58	55.32
T_6	53.19	112.93	7.74	41.88	54.98
SEm±	1.89	3.50	0.28	1.55	1.59
CD (p=0.05)	5.46	10.11	0.82	4.46	NS

3.2. Yield attributes and yield

Yield contributing characters *viz*., pod length, number of pods plant^{-1}, Number of seeds pods^{-1} and pod yield (g plant^{-1}). However, pod length and number of seeds pods^{-1} being a varietal character showed non significant effect of treatments (Table 5). On two year pooled basis, application of 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM (T_1) gave significantly more number of pods plant^{-1} and pod yield plant^{-1} found superior as compared to other treatments. It could be due to combined application of organics and inorganics resulted in better nutrient absorption, translocation and assimilation as well as better partitioning of photosynthates between source and sink resulted in improvement of all the growth attributes and finally enhance the all above mentioned yield attributes resulting in greater dry matter assimilation in the reproductive or fruiting parts. However, in case of pod length and number of seeds pod^{-1} were not affected by INM treatment applied to the Indian bean. Despite this, treatment T_6 reported lower values in all the yield attributes.

Table 5: Yield attributes and yield of vegetable Indian bean as influenced by as influenced by different INM treatments

Treatments	PL	NPP	NSP	PY	PY*	SY
T_1	3.77	82.85	4.13	76.19	3422	3524
T_2	3.67	66.37	3.77	65.32	2701	2953
T_3	3.75	73.89	4.10	67.44	3055	3142
T_4	3.57	63.59	3.71	61.91	2596	2892
T_5	3.77	69.80	3.85	66.41	2813	3060
T_6	3.53	62.00	3.33	59.40	2503	2689
SEm±	0.08	1.78	0.16	1.97	81.12	86.47
CD (p=0.05)	NS	5.14	NS	5.70	234.29	249.75

PL: Pod length (cm); NPP: No. of pods plant^{-1}; NSP: No. of seeds pods^{-1}; PY: Pod yield (g plant^{-1}); PY*: Pod yield (kg ha^{-1}); SY: Stover yield (kg ha^{-1})

Pod yield (kg ha^{-1}) and stover yield (kg ha^{-1}) of vegetable Indian bean was significantly influenced by the treatments (Table 5). An application of 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM (T_1) were found to be significantly superior with respect to pod yield (3422 kg ha^{-1}) and stover yield (3524 kg ha^{-1}) as compared to other treatments in two year pooled findings. The ultimate results of various interacting growth factors (i.e., plant height, number of leaves, number of branches and dry matter accumulation) and yield contributing characters (*i.e.,* pod length, number of pods plants^{-1}, number of seeds pod^{-1} and pod yield plant^{-1}) increased consistently and significantly with combination of inorganic and organic sources. It may also due to the adequate uptake of major nutrients, which are required in greater quantities and the use of FYM in treatment T_1 served as a reserve for macro and micro nutrients that are released during the mineralization process and finally it improved the green pod as well as stover yield. These results were in accordance with those of Mere et al. (2013) reported that application of 125% RDF+FYM 5 t ha^{-1} was found more effective in enhancing the seed yield of soybean and produced 19.11% higher seed yield over 100% RDF with respect to soybean. Beg and Singh (2009) reported that the treatments comprised: no N or P_2O_5; 10 kg N+30 kg P_2O_5 ha^{-1}; 20 kg N+45 kg P_2O_5 ha^{-1}; and 30 kg N+60 kg P_2O_5 ha^{-1} has reported higher pods plant^{-1}, seeds pod^{-1} and seed yield in soybean. Ananth and Kumar (2018) reported the highest yield parameters and pod yield (15.5 t ha^{-1}) were observed in treatment combination of 5 t Vermicompost ha^{-1}+75% RDF+CBF (2 kg *Rhizobium* ha^{-1}+2 kg VAM ha^{-1}+2.5 kg PSB ha^{-1}) in Dolichus bean. Jaisankar and Manivannan (2018) reported that the treatment with NP 30:50 kg ha^{-1}+5 t VC ha^{-1}+BF 2.5 each kg ha^{-1} recorded significantly highest pods plant^{-1}, pod yield plant^{-1}, and pod yield (9.88 t ha^{-1}) in Indian bean. While, the lowest values were obtained under the treatment T_6. Almost all these yield attributes remained in the T_1>T_3>T_5>T_2>T_4>T_6 order of their significance.

3.1.3. Economics

The data tabulated in Table 6 revealed that maximum net realization of ₹ 87277 with BCR of 2.03 was noticed under the treatment T_1 (100% RDN through chemical fertilizer+5 t ha^{-1} of FYM) followed by treatment T_3 (75% RDN through chemical fertilizer+25% RDN through biocompost+seed treatment with PSB and *Rhizobium* biofertilizers) with net realization of ₹ 77264 with BCR value of 1.98 and T_5 (50% RDN through chemical fertilizer+50% RDN through biocompost+seed treatment with PSB and *Rhizobium* biofertilizers) with net realization of ₹ 67618 with BCR value of 1.69. This is mainly because of the higher yields and reasonable cost in INM treatments. Similar results were also reported by Patel et al. (2016) with regards to green gram. The lowest net realization of ₹ 53870 was noted under the treatment T_6 (100% RDN through biocompost) with BCR value of 1.29.

Table 6: Economics of vegetable Indian bean as influenced by different INM treatments

Treatments	Yield (kg ha^{-1})		Cost (₹ ha^{-1})		Cost of cultivation (₹ ha^{-1})	Gross monetary returns (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C ratio
	Green pod	Stover	Fixed	Variable				
T_1	3422	3524	35974	7108	43082	130359	87277	2.03
T_2	2701	2953	35974	3042	39016	103405	64390	1.65
T_3	3055	3142	35974	3104	39078	116342	77264	1.98
T_4	2596	2892	35974	3975	39949	99520	59571	1.49
T_5	2813	3060	35974	4038	40012	107629	67618	1.69
T_6	2503	2689	35974	5843	41817	95687	53870	1.29

*Selling price of green pod- ₹ 35 kg^{-1}, stover- ₹ 3 kg^{-1}, Cost of input: FYM- ₹ 1.00 kg^{-1}, biocompost- ₹ 0.80 kg^{-1}, Urea- ₹ 6.10 kg^{-1} and SSP- ₹ 7.37 kg^{-1}; 1 US$=INR 71.58, 1US$=INR 72.82 (average of February 2020 and 2021)

3.2. Residual effect of INM and direct application of RDF levels on succeeding fodder pearl millet

3.2.1. Growth parameters and yield parameters

On two-year pooled data basis, the residual effect of of 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM (T_1) has significantly recorded higher values for almost all the growth attributes in fodder pearl millet but it remained on par with treatments T_6 (100% RDN through biocompost) and T_5 (50% RDN through chemical fertilizer+50% RDN through biocompost+seed treatment with PSB and *Rhizobium* biofertilizers) (Table 7). This could be due to residual effect of FYM and biocompost applied in the preceding vegetable Indian bean. Since organic sources release nutrients at a slower rate than inorganic sources thus, nutrients are available to crops for longer period of time. Since, FYM and biocompost were not fully utilized by the vegetable Indian bean in the first cropping season, but notably benefited the succeeding fodder pearl millet by enhanced nutrient availability under INM treatments, which resulted in increased conversion of carbohydrates into protein, which in turn developed into protoplasm and cell wall material, increasing cell size, which reflected morphologically in terms of plant height, number of leaves, number of internodes, length of internodes, leaf: stem ratio and ultimately dry matter accumulation. Furthermore, the preceding vegetable Indian bean acted as a green manure. Green manuring with legumes is known to recycle nutrients from the lower soil depths in addition to symbiotic nitrogen fixation. Thus, the beneficial effect of these INM treatments were observed in the succeeding fodder pearl millet owing to better vegetative growth and development of growth attributes.

Table 7: Growth parameters of fodder pearl millet at harvest as influenced by different treatments

Treatments	Plant height (cm)	No. of leaves plant^{-1}	Length of internodes plant^{-1} (cm)	No. of internodes plant^{-1}	Leaf: stem ratio	Dry matter accumulation (g plant^{-1})	Green fodder yield (kg ha^{-1})	Dry fodder yield (kg ha^{-1})
Main plot treatments								
T_1	209.49	23.57	19.02	15.68	0.729	214.14	38424	9304
T_2	175.07	19.88	14.73	14.02	0.609	175.40	30343	7338
T_3	182.53	20.76	16.49	14.51	0.634	183.44	31884	7711
T_4	190.33	22.13	16.82	14.85	0.653	192.64	33549	8113
T_5	196.69	22.89	18.12	15.11	0.684	200.55	35020	8470
T_6	202.88	23.04	18.99	15.45	0.704	206.77	36052	8719
SEm±	4.87	0.48	0.50	0.23	0.016	5.12	628.24	156.18
CD (p=0.05)	14.09	1.40	1.44	0.66	0.046	14.79	1815	451
Sub-plot treatments								
F_1	166.54	21.19	15.99	14.41	0.633	169.92	28770	6958
F_2	203.87	21.26	17.87	15.11	0.685	206.61	36885	8921
F_3	208.08	22.44	18.22	15.28	0.688	209.93	36981	8949
SEm±	3.16	0.35	0.31	0.15	0.010	3.08	406.16	101.10
CD (p=0.05)	8.91	1.01	0.89	0.44	0.029	8.67	1145	285
Interaction (T×F)								
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

T_1: 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM; T_2: 75% RDN through chemical fertilizer+25% RDN through biocompost,T_3: 75% RDN through chemical fertilizer+25% RDN through biocompost+biofertilizers (PSB+*Rhizobium*) as a seed treatment; T_4: 50% RDN through chemical fertilizer+50% RDN through biocompost; T_5: 50% RDN through chemical fertilizer+50% RDN through biocompost+biofertilizers (PSB+Rhizobium) as a seed treatment; T_6: 100% RDN through biocompost; F_1: 50% RDF; F_2: 75% RDF; F_3: 100% RDF

Similarly, application of 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM (T_1) gave higher green fodder (38424 kg ha^{-1}) and dry fodder yield (9304 kg ha^{-1}) of pearl millet and was found to be better as compared to other treatments (Table 7). It may be attributed to enhanced nutrient availability owing to mineralization of organic materials, CO_2 release, better nutrient efficiency, organic carbon buildup and improved soil properties. Although, the addition of FYM or biocompost to the preceding vegetable Indian bean improved soil structure, reduced soil crusting and served as a source of energy for soil microflora resulting in improved root nodulation and nitrogen fixation and also due to increase in vegetative growth in terms of plant height, number of leaves, length of internodes, number of internodes, leaf: stem ratio and dry matter accumulation. Since the persistent material in organic manures (FYM and biocompost) takes a long time to decompose, approximately 25–33% of nitrogen and a small fraction of phosphorus and potassium in FYM and biocompost may be available to the immediate crop (vegetable Indian bean) and the remaining part to subsequent crop (fodder pearl millet) that sustain productivity. Similar results reported earlier by in Shivakumar and Ahlawat (2008) indicated that residual application of 5 t ha^{-1} each of crop residues (CR) and farmyard manure (FYM) along with 5 kg zinc ha^{-1} among the nutrient sources soybean and 100% recommended dose of fertilizer (RDF) to wheat recorded significantly higher growth and yield parameters and yield (1.62 t ha^{-1}) of wheat in soybean-wheat cropping system. Virkar and Tumbare (2008) revealed that application of RDF (50 kg N+75 kg P2O5 ha^{-1})+5 t FYM ha^{-1}+biofertilizers (*Rhizobium*+PSB) to preceding crop soybean and 100% recommended dose of fertilizers+ biofertilizers (Azotobacter+PSB) to wheat crop produced significantly higher grain (42.25 q ha^{-1}) and straw (53.17 q ha^{-1}) yield in soybean-wheat cropping sequence. Prajapat et al. (2014) reported that the application of 25% RDF+50% RDN through FYM+biofertilizers to soybean and application of 50% RDF and 50% RDN through FYM gave higher fodder yield in fodder sorghum in soybean-fodder sorghum sequence.

On two year pooled data basis, application of 100% RDF (F_3) showed significantly higher values with respect to all growth parameters *viz.*, plant height, number of leaves $plant^{-1}$, length of internodes $plant^{-1}$, number of internodes $plant^{-1}$, leaf: stem ratio and dry matter accumulation but it remained at par with treatment F_2 (75% RDF) (g $plant^{-1}$) as compared to treatment F_1 (50% RDF) (Table 7). The increase trend in the growth parameters of fodder pearl millet were observed under higher level of RDF may be attributed due to increased cell division, cell elongation, increased leaf area and prolonged vegetative growth which resulted in better plant growth and internodal elongation. Nitrogen is the integral part of chlorophyll and is essential for photosynthesis resulted in more plant height. The increase in leaf: stem ratio with increasing levels of RDF was mainly due to rapid expansion of dark green foliage which could intercept and utilize the incident solar radiation resulted in more photosynthates accumulation and eventually resulting in higher meristematic activity and increased leaf: stem ratio and ultimately to higher dry matter accumulation.

Similarly, application of 100% RDF (F_3) showed significantly higher values of green fodder and dry fodder yield of fodder pearl millet but it remained at par with treatment F_2 (75% RDF) as compared to treatment F_1 (50% RDF) (Table 7). This may be ascribed mostly due to the higher N received by plants and it is fact that the nitrogen is directly involved in cell division, elongation, nucleotide and co-enzyme formation, which resulted in increased meristematic activity and it also an integral part of chlorophyll, which plays an important role in photosynthetic activity of leaves attributed to the most lucrative consumption of applied nitrogen leads to better uptake of nutrients which helped to accumulate more biomass. Although, increase in fodder yield with increased nitrogen was mainly associated with growth parameters such as plant height, number of leaves, internode number, internode length, leaf: stem ratio and dry matter accumulation. These results are on the line with the findings of Hegde et al. (2006) reported that the application 120 kg nitrogen and 60 kg phosphorous gave higher growth and yield in fodder pearl millet. Crawford et al. (2018) reported that the application of 120 kg N ha^{-1} gave significantly higher growth and yield characters in forage sorghum. Eltelib et al. (2006) reported that the application of 80 kg N and 100 kg P_2O_5 higher growth and yield in forage maize. Meena and Jain (2013) reported that application of 120 kg ha^{-1} nitrogen to fodder pearl millet recorded higher growth and yield parameters. Kaur et al. (2017) reported that application 100 kg ha^{-1} to napier bajra recorded higher growth and yield parameters.

3.2.2. Economics

The data in Table 8 revealed that the application of 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM (T_1) resulted in higher net returns of ₹ 88037 ha^{-1} and B:C ratio of 3.23 followed by 100% RDN through biocompost (T_6) with net returns of ₹ 80921 ha^{-1} and B:C ratio of 2.97 and 50% RDN through chemical fertilizer+50% RDN through biocompost+seed treatment with PSB and *Rhizobium* (T_5) with net returns of ₹ 77826 ha^{-1} and B:C ratio of 2.86. This has clearly brought out that application of inorganic fertilizers along with organic manures (FYM) to preceding vegetable Indian bean has an additional advantage to enhance the overall net monetary returns of fodder pearl millet. Similar benefits of residual effect of INM were reported earlier by Samborlang et al. (2019) in vegetable pea-maize.However, treatment T_2 (75% RDN through chemical fertilizer+25% RDN through biocompost) yielded the lowest net returns of ₹ 63795 ha^{-1} with B:C ratio of 2.34.

Table 8: Economics of fodder pearl millet as influenced by different treatments

Treatments	Green fodder yield (kg ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross monetary returns (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C ratio
Main plot treatments (INM to vegetable Indian bean)					
T_1	38424	27235	115272	88037	3.23
T_2	30343	27235	91030	63795	2.34
T_3	31884	27235	95653	68418	2.51
T_4	33549	27235	100647	73412	2.70
T_5	35020	27235	105061	77826	2.86
T_6	36052	27235	108156	80921	2.97
Sub-plot treatments (RDF to fodder pearl millet)					
F_1	28770	26903	86311	59408	2.21
F_2	36885	27235	110655	83420	3.06
F_3	36981	27566	110943	83377	3.02

According to the average of two years pooled result of fodder pearl millet, the higher net returns of ₹ 83420 ha^{-1} and B:C ratio of 3.06 was obtained under the treatment receiving 75% RDF (F_2), followed by 100% RDF (F_3) with net returns of ₹ 83377 ha^{-1} and B:C ratio of 3.02. Although, the lowest net realization of ₹ 59408 ha^{-1} and B:C ratio of 2.21 was reported under 50% RDF (F_1) treatment (Table 8). This might be due to higher yield of fodder pearl millet. Thus, evaluation of all measurable sources proved that application of 75% RDF (F_2) was found better for securing higher profit as compared to 100% RDF (F_3) by saving 25% recommended dose of fertilizer to fodder pearl millet. Similar results were also reported by Hooda et al. (2004), Although, the lowest net realization of ₹ 59408 ha^{-1} and B:C ratio of 2.21 was reported under 50% RDF (F_1) treatment. However, the interaction effect was found to be non significant with respect to growth, yield and economics.

4. CONCLUSION

Application of 100% RDN through chemical fertilizer+5 t ha^{-1} of FYM to vegetable Indian bean had significant effect on growth, yield attributes and yield and economics. Residual effect of various integrated nutrient management practices applied to preceding vegetable Indian bean had significant residual effect on growth, yield attributes and yield and economics of succeeding fodder pearl millet. Among direct application of 100% RDF through chemical fertilizers resulted in significantly higher values of growth parameters, yield attributes and yield and economics of succeeding fodder pearl millet.

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